

DMSMS Conference 2013

***Supply Chain Modeling: Downstream Risk
Assessment Methodology (DRAM)***

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IDA | Agenda

- **Background**
- **Modeling Objectives**
- **Description of Approach**
 - Modeling supply chains
 - Relating downstream shortfalls to risk
- **Capability Demonstration Cases**
- **Observations**
- **Conclusions**

IDA | Background

- Work sponsored by Defense Logistics Agency - Strategic Materials
- Build and implement for DLA SM and DoD an analytically rigorous risk-based process that can help DoD set priorities for risk mitigation (preparedness and investments) concerning strategic and critical non-fuel materials
 - Process began as raw material shortfall estimation to support National Defense Stockpile (NDS) planning
 - The Risk Assessment and Mitigation Framework for Strategic Materials (RAMF-SM) extended shortfall estimation and stockpile planning into risk assessment and mitigation (beyond stockpiling)
- Downstream Risk Assessment Methodology for strategic materials (DRAM) is now extending RAMF-SM into risk assessment and mitigation for *supply chains* downstream of raw material production

Objective for Today's Presentation

- Present DRAM capability and demonstrate its operation

IDA | Develop DRAM (Downstream Risk Assessment Methodology) — Objectives

- **Represent each important production step in global supply chain**
- **Estimate supply and demand at each step (node) in each supply chain on time-phased basis under conditions of National Defense Stockpile planning scenario (or others of interest)**
- **Model response of supply chain nodes to demand for goods, node capacity limits, and quantity of necessary feedstock material available to each node**
- **Model material shortfall risk mitigation measures applicable at each node of supply chain**
- **Reflect longer-term changes in technology, market, and security environment (alternative futures) in scenario conditions**
- **Quantitative approach is necessary to more precisely assess risk and evaluate and support proposed risk mitigation measures**

Develop DRAM—Approach

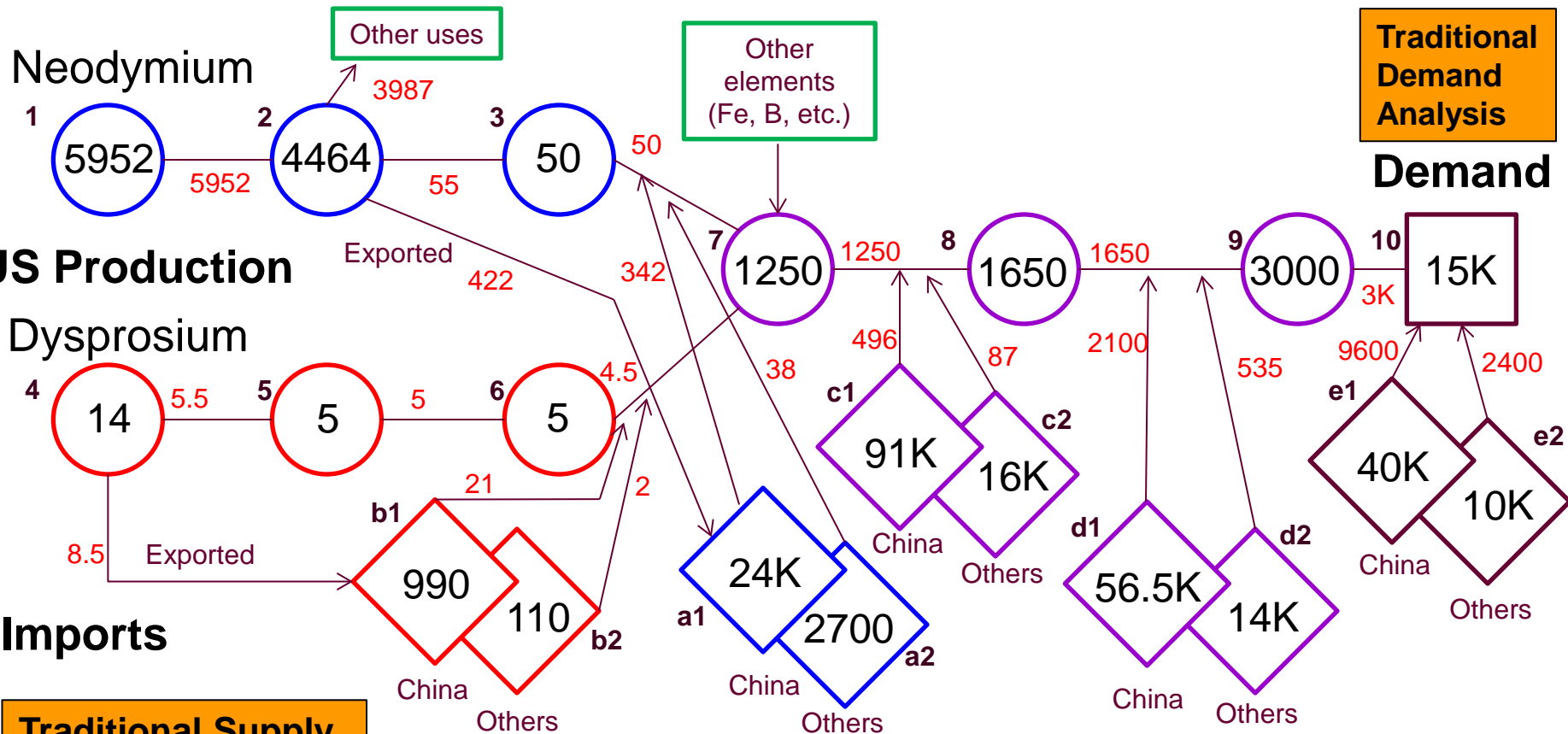
- **Use neodymium iron boron magnet supply chain as basis for prototype**
- **Conduct literature review and canvass experts to identify desirable characteristics of supply chain model, approaches to modeling, and potential challenges**
- **Build model with characteristics to satisfy objectives**
 - **Material flows through nodes and shortfall estimation**
 - **Treatment of shortfall risk mitigation measures**
- **Demonstrate prototype DRAM using NdFeB magnets**

Supply Chain Prototype: NdFeB Magnets

Legend: Node Capacity & Material Flows (MT/yr)

Stages of Production

Ore Mining	Separated Oxide Production	Metal Production	Alloy Production	Magnet Production	Magnet Fabrication
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Traditional Supply Analysis

Supply Chain Analysis

IDA | Relating Downstream Material Shortfalls to Risk

- **Risk is defined as possibility of loss/harm:**
 - *Risk = Probability of material shortfall x Consequences*
- **Probability of shortfall is, to first order, probability of scenario**
- **Consequences of shortfall in DRAM are consequences of shortage of final product**
 - **Consequences of “mid-stream” shortages are reflected in shortages of final products**
 - **Potential approaches to assessing consequences of final product shortfalls include:**
 - **Expert judgment**
 - **Elasticity of demand**
 - **Long-term price**
 - **Cost of production**

IDA | Cases Demonstrated

- *Peacetime supply and demand*
- Cutoff of imports from China
- Cutoff of imports from China with increased demand
- No imports (closed economy)
- *No imports and failure of U.S. sole source*

Demonstrations include product output, material flows, and shortfalls (if any)

Mitigation measures are demonstrated, with costs estimated, where shortfalls are found

Mitigation measure choices can be optimized for cost-effectiveness

DRAM quantitative approach enables more precise risk assessment and evaluation and support of proposed risk mitigation measures

Cases Presented in Today's Briefing

IDA | Material Shortfall Mitigation Measures

- *Traditional government stockpiling*
- *Other federal (or private) inventory options*
- *Spot market purchases*
- **Futures contracts**
- **Reductions in government supply guarantees for exports**
- *Substitution*
- *Concerted material production programs (e.g., Title III)*
- **Enhanced recycling**
- **Security of foreign supply arrangements**

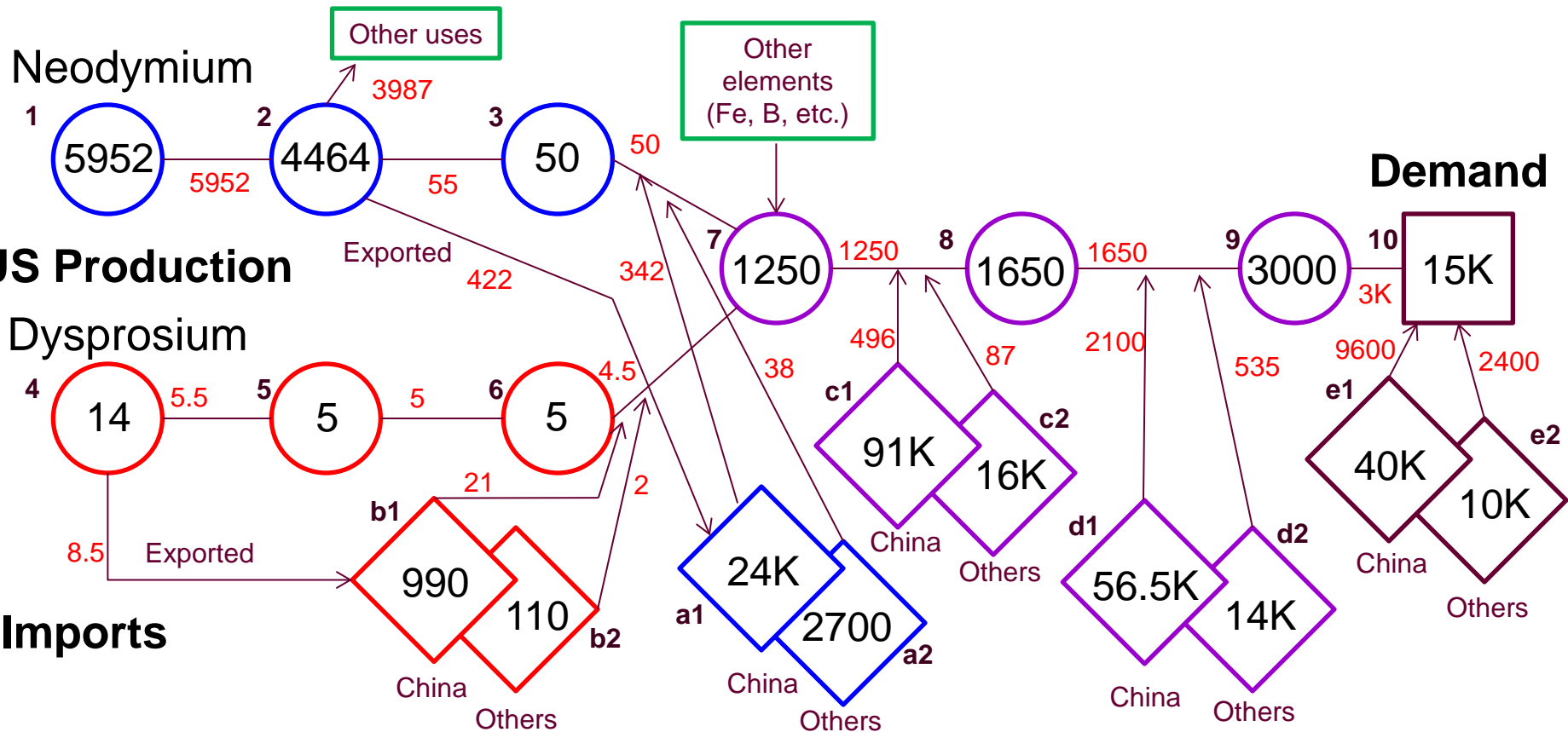
Included in Today's Briefing

Peacetime Supply and Demand Case

Legend: Node Capacity & Material Flows (MT/yr)

Stages of Production

Ore Mining	Separated Oxide Production	Metal Production	Alloy Production	Magnet Production	Magnet Fabrication
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IDA | Peacetime Supply and Demand Observations

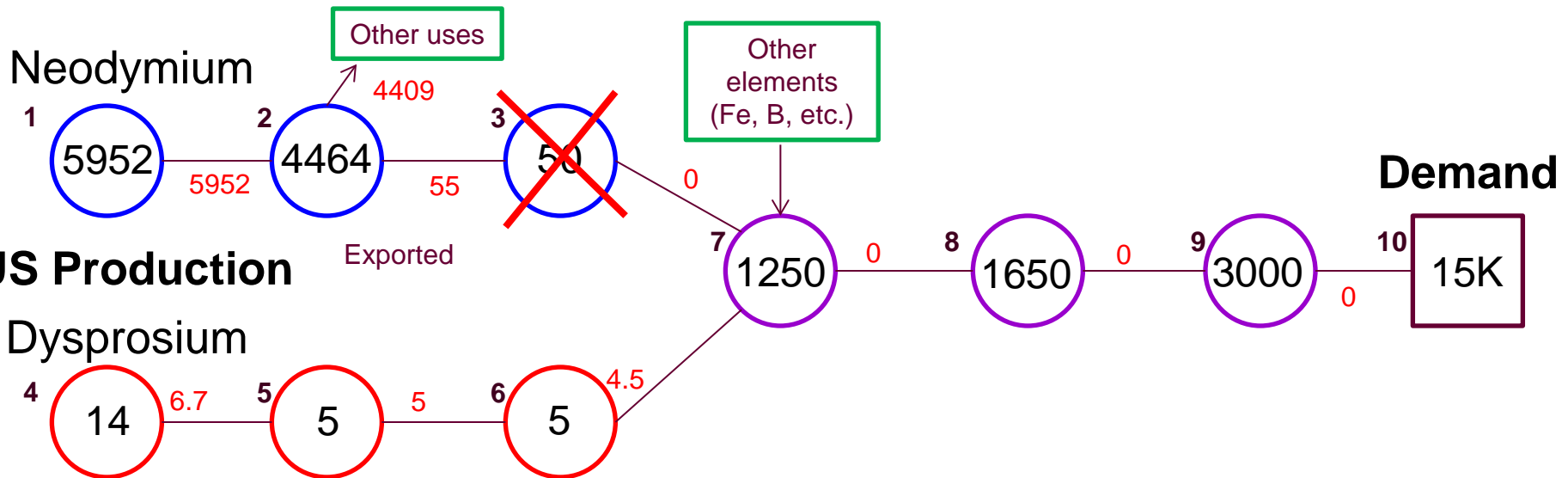
- **Peacetime case shows material/product flows and production under normal conditions**
- **Demand met by combination of U.S. production and imports**
- **Material flows driven by demand for finished goods and requirements for producing upstream products, including process losses**
- **Imports feed U.S. supply chain at several points**
- **Imports sufficient to meet U.S. demand so long as U.S. market share is at least 24 percent**

No Imports with Sole Source Cutoff Case

Legend: Node Capacity & Material Flows (MT/yr)

Stages of Production

Ore Mining	Separated Oxide Production	Metal Production	Alloy Production	Magnet Production	Magnet Fabrication
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No Imports

No Imports with Sole Source Cutoff Case Observations

- **Imports not available at all and sole source node cut off**
 - **Severe scenario for demonstrating modeling capability**
- **U.S. supply chain output constrained by lack of upstream capacity at several nodes**
- **One node—Nd metal production—is cut off entirely**
 - **Loss of critical node cuts off all US production of final product**
 - **All but Nd ore and oxide production insufficient to meet final demand**
- **Resulting shortfall = 15,000 MT magnets**
- **Mitigation measure(s) required at one or more nodes**
 - **Stockpiling**
 - **Other Inventory options (e.g., Buffer stock)**
 - **Spot market purchases**
 - **Substitution**
 - **Concerted Program (magnet production and fabrication)**

No Imports with Sole Source Cutoff Case Analytical Assumptions

Assumptions generally consistent with those used in last National Defense Stockpile Requirements Report

- **One year shortfall in 4-year scenario**
- **Planning horizon = 5 years**
- **U.S. market share = 0% (no imports)**
- **Wartime price multiple = 15**
- **Probability of war = 0.0037**
- **Buffer stock rental cost = 15%/yr**
- **Cost = budget outlays (no recoupment)**

No Imports with Sole Source Cutoff Case

Shortfall Risk Mitigation Options

Risk mitigation options: indicated below – including inventory sufficient to enable full use of existing U.S. production capacities

Inventory amounts:

- **Nd metal: 430 MT**
- **Dy oxide: 0.5 MT**
- **Dy metal: 22.5 MT**
- **Magnet alloy: 583 MT**
- **Magnet block: 2,635 MT**
- **Fabricated magnets: 12,000 MT**

Mitigation Measure	Amount Provided (MT)	Expected Cost (Budget) (\$M)
Stockpiling	Amounts above	3,848
Inventory	Amounts above	2,900
Spot Market	0 (no imports)	0
Substitution	1,500 (magnets)	0
Conc. Program (magnet production)	0**	0

**No extra feedstock available

No Imports with Sole Source Cutoff Optimal Risk Mitigation Solution

- Shortfall mitigation options optimized for cost effectiveness
- Optimal measures under assumptions stated above
- Mitigation measure priority same as 2013 NDS Requirements Report

Mitigation Measure	Amount Provided (MT)	Expected Cost (Budget) (\$M)
Substitution	1,500	0
Inventory (magnets)	10,500	2,074
Inventory (block)	2,635	459
Inventory (alloy)	583	35
Inventory (Dy metal)	22.5	13
Inventory (Dy oxide)	0.5	0.3
Inventory (Nd metal)	430	23
Total	15,000 (magnets)	2,604

IDA | Modeling Observations

- **Loss of sources within supply chain can create shortfalls depending on redundancy of network and U.S. market share of imports**
 - **Loss of single node could prevent production of final product**
- **Different mitigation measures may not be suitable for some nodes and scenarios (e.g., substitution, spot market)**
- **Capacities of nodes in domestic supply chains may not be balanced for self-sufficiency**
 - **Shortfall mitigation at multiple nodes may be required to allow production of final product at full domestic capacity**
 - **Options for shortfall mitigation may exist at multiple mid-stream nodes as well as final downstream node**
 - **Relative costs of shortfall mitigation at different nodes (e.g., mid-stream, downstream) may vary depending on material and nature of production process**

- **Modeling capabilities demonstrated**
 - **Supply chains with material flows for multiple materials and multiple material suppliers**
 - **Multiple scenario conditions**
 - **Peacetime material flows**
 - **Increased demand**
 - **Cutoffs of material supplies from specified sources or all sources, including domestic**
 - **Shortfall risk mitigation measures evaluated**
 - **Applicable node by node and material by material**
 - **Effects on individual material flows, production of goods, and mitigation costs calculable**
 - **Can be optimized using specified priorities or to minimize cost or risk**
- **DRAM will be used to assess risk and evaluate mitigation measures for supply chains for FY 2015 NDS Requirements Report**

BACK-UP

RAMF-SM Process and Steps

